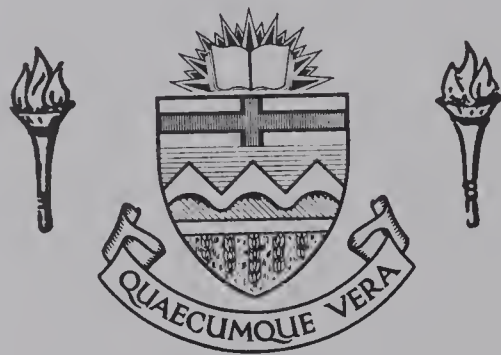


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PERCEPTUAL PREFERENCE, PERCEPTUAL FAMILIARITY,
AND IMPRINTING

by



ALLEN DOUGLAS HOLMES

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Perceptual Preference, Perceptual Familiarity, and Imprinting" submitted by Allen Douglas Holmes in partial fulfilment of the requirements for the degree of Master of Science.

Abstract

One of the distinctive features of the imprinting process which distinguishes imprinting from other forms of learning is that it can only take place during a brief period in the life of the organism referred to as the critical period. Most authors agree that the end of the critical period is brought about by a progressive interference of fear responses with the approach response to the imprinting stimulus. Two explanations for the increase in fear responses have been suggested. The perceptual model suggests that imprinting brings about its own end since fear responses are a function of imprinting. The maturational model maintains that the increase in fear responses is due to physiological maturation.

In the present experiment the two models were evaluated under conditions of pre-hatch familiarity with the imprinting stimulus or with another stimulus.

Aspects of both models were supported while both models revealed deficits. A maturational-perceptual model combining the good aspects of the two models while relieving their deficits was therefore proposed.

An unexpected limitation of the perceptual model was revealed by the finding of an unanticipated 'boredom' effect associated with prolonged pre-hatch perceptual familiarity.

The suggestion that the effect of pre-hatch perceptual familiarity would depend on the S's innate preference for the stimulus received only minor support.

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Introduction

The German ornithologist Lorenz noted that goslings and other young birds would form an attachment to him rather than to their mother if he presented himself to them shortly after hatching while preventing the mother from seeing them during this period. He coined the term *Pragung* (imprinting) to describe the process responsible for this phenomenon.

Lorenz maintained that

"...imprinting has two properties which distinguishes it from other types of learning, first, it can only take place during a specific and brief portion of the life span while the organism is in a critical physiological stage of development, and second, the results of imprinting are irreversible throughout the life of the individual." (Beach & Jaynes, 1954)

Attributing the first of these two properties to the imprinting process is referred to as the critical period hypothesis. Investigation of this hypothesis is usually based on an assessment of the efficacy of the imprinting process as indexed by some measure (distress calls, defecation, immobility, withdrawal, following, etc.) of attachment taken at various short intervals either after an initial imprinting exposure or during the initial exposure. Evaluations have been made either under the same conditions as the initial exposure or in terms of preference in a free choice situation (i.e., the subject (S) is presented a number of objects in an open field and is free to move toward whichever object he

chooses. If the evaluation takes place after an initial exposure, one of the objects will be that to which S was initially exposed.) Such variations have resulted in different conclusions being drawn about the nature and boundaries of the critical period, but in general it has been agreed that such a period exists (Fabricius, 1951; Ramsay & Hess, 1954; Beach & Jaynes, 1954).

The end of the critical period is evidenced by the appearance of a withdrawal response rather than an approach response to the imprinting object upon initial exposure. Hess (1959b) suggested that the end of the critical period is brought about by the maturation of the fear response. He measured the percentage of Ss showing a fear response (either a distress call or a movement away from the decoy) in nine successive four hour age groups from one to 36 hours old. The onset of fear began in the 13 to 16 hour age group with 10% of the chicks (White Rocks) showing fear responses and followed by a slightly sigmoid increase to 100% showing fear responses in the 33 to 36 hour age group. (Chicks were raised in the dark, transported to the experimental apparatus in the dark, placed in the apparatus in the dark, then given a 10 minute test with lights on.) Combining the fear onset curve with a similarly determined locomotor development curve resulted in a predicted peak for the critical period at 13 to 16 hours. This agreed well with experimental results obtained earlier (Ramsay & Hess, 1954). Hess concludes that the "development of fear responses leads to a decrease of imprinting".

The causal situation envisioned by Hess can be represented by a path diagram as shown in Figure 1. (For a discussion of the use of path diagrams in depicting causal structure, see Land, 1969.)

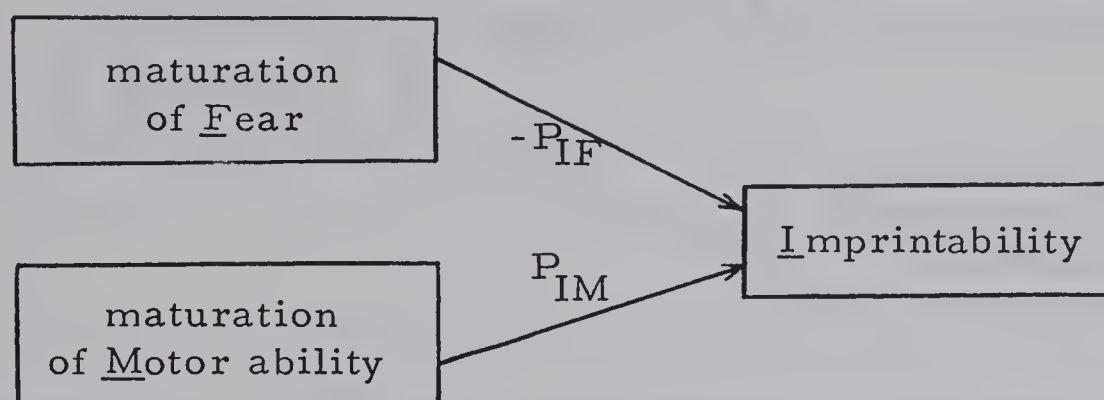


Figure 1. Maturational model: Imprintability as a function of fear and motor development.

In this diagram, imprintability is indicated as a positive function (P_{IM}) of the maturation of motor ability and as a negative function ($-P_{IF}$) of the maturation of fear. Since maturation of motor ability preceeds maturation of fear, imprintability is highest at a critical period when motor development is high and the development of fearfulness is low.

It has, however, been suggested that fear (withdrawal) and 'imprinting' (following) are actually two aspects of a single process (Moltz, 1960; Moltz & Stettner, 1961; Salzen, 1962; Schneirla, 1959). Fear is conceived of as a response to the unfamiliar (cf. Hebb, 1946) and approach as a response to the familiar, the unfamiliarity of a stimulus being judged in relation to the standard provided by the perceptually familiar.

A path diagram showing the causal situation envisioned is given in Figure 2.

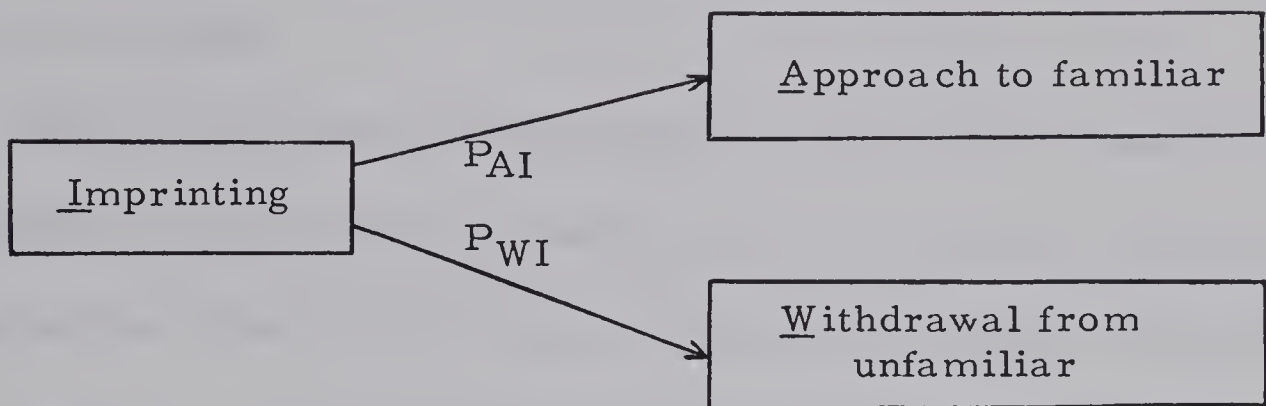


Figure 2. Perceptual model: Approach and withdrawal behavior as a function of imprinting.

In Figure 2 both the fear response (withdrawal) and the following response (approach) are shown as causal functions of the imprinting (perceptual learning) process. This causal relationship, in which fear is a function of imprinting, stands in sharp contrast to the causal relationship hypothesized by the maturational model. In the latter model imprinting is considered as a function of the maturation of fear.

The following section reviews the data and conclusions relevant to the perceptual model of behavior in the 'imprinting' situation.

Perceptual Familiarity and Imprinting

Moltz and Stettner (1961) studied the effect of deprivation of patterned-light stimulation. They found that covering the chick's head with a latex hood that prevented patterned-light reaching the eyes

resulted in an extension of the critical period as indicated both by the following response and the initial avoidance response. Ss were tested 12-, 24-, 48-, and 72-hours post-hatch and wore the hood right up until the test period.

Moltz and Stettner attributed this result to the prevention of the development of a structured perception of the environment. Salzen (1962) investigated the effect of allowing a structured perception of the environment to develop. He demonstrated that all chicks exhibit a fear response when first exposed to the imprinting situation. He attributed this to the drastic shift from their established environments i.e., incubator or cage. Bateson (1964a) investigated the effect of perceptual familiarity with certain characteristics of the imprinting object. He found that Ss tested with a moving model painted with a pattern similar to the pattern present in their rearing cage avoided the model less and followed it sooner than Ss tested with a model painted with a different pattern.

Broom (1966) found that the general response of chicks to a novel stimulus (the illumination of a six-volt bulb) was a period of reduced activity and immobility, followed by a period of increased activity. The period of reduced activity increased as the birds grew older. Of 12 measures of activity taken before light-on and again three minutes after light-on there were significant decreases in frequency of two measures at 1.5 days, four at 5.5 days, and eight at 10.5 days. He concluded that these observations were in accord with the view that reactions to

a novel stimulus are a function of the degree to which the experience is novel, i.e., the reaction is a function of "the extent to which the birds have learned the characteristics of their familiar environments".

In a free choice situation (as described in the introductory section of this paper) a number of studies have shown that chicks exhibit a preference for the perceptually familiar. Baer and Gray (1960) emphasize that too much attention has been paid to the following response and suggests that the operational definition of imprinting should be "an acquired ability to discriminate the object to which the young animal has been sufficiently exposed at a critical age". Baer and Gray confined White Rock chicks in small compartments with glass fronts through which they could observe either a black or a white guinea pig for 24 hours. When not so exposed chicks were kept in the dark. Chicks were exposed 1, 2, 3, or 4 days after hatching and were tested seven days after hatching. For the test they were placed for 30 minutes in a compartment exposing the black guinea pig at one side and the white guinea pig at the other. The floor of the compartment was pivoted and micro-switches recorded the time spent in the proximity of each guinea pig. All chicks showed significant ability to discriminate by spending more time in the proximity of the familiar guinea pig. The chicks exposed on the second day after hatch showed the best ability. Baer and Gray concluded that "Imprinting is not a learning to follow, but a learning of the characteristics of the parent-

object which enables the infant animal to distinguish this object from one similar." They also warn that "success or failure in eliciting the following response does not adequately reflect the learning itself in imprinting. Our data indicate that imprinting is possible even beyond the age where following may no longer be provoked in naive chicks...."

Smith and Hoyes (1961) allowed chicks to approach either a rotating white disc with a black sector or a flashing light (0.5 seconds on : 0.5 seconds off) three times each day for seven successive days post-hatch. On the eighth day the chicks were placed in a darkened room at one vertex of a 10 foot equilateral triangle with the two stimuli located at the remaining two vertices of the triangle. All chicks moved toward the familiar stimulus and remained in its vicinity.

Candland, Nagy and Conklyn (1963) investigated the relationship between the environment experienced during development and the emotional reaction of chicks to a novel stimulus. Chicks were reared, a) in isolation, b) with manipulable objects, c) communally, d) communally with manipulable objects. The Ss were raised under these conditions from 24 hours old to 25 days old. At 25 days of age the chicks were placed in a free choice open field situation in which there were manipulable objects in one sector, another chick in a second sector, and a robot toy with revolving head emitting flashing light, swinging arms and clicking noise in the third sector of the circle. The chick was placed at the center of the circle and the time spent in proximity

to each of the three stimuli was recorded. It was found that the communally raised chicks spent most of their time near the other chick present, the objects reared group spent most of their time with the objects, the communal-objects reared group chose either the chick or the objects and the isolated group showed no preference for either the chick or the objects and showed the greatest incidence of elimination and of freezing (not moving from the center over the two minute duration of the test). Candland et al. conclude that "...the chicken has no special preference for another chicken, but...will approach any stimulus to which he has become accustomed in his environment".

Tallarico and Farrell (1964) studied the effect of early experience on chicks exposed to a visual cliff. Three groups of chicks were raised for approximately 35 hours in, a) a normal brooder, b) the 'deep' side of a visual cliff apparatus, or c) the 'shallow' side of a visual cliff apparatus. After 35 hours, chicks were removed from their rearing quarters and tested for 10 minutes in a visual cliff apparatus. It was found that Ss reared in the deep side tended to move toward the deep side and that this behavior was significantly different than that of chicks raised on the shallow side, who tended to move to the shallow side, and chicks reared normally, who showed a marked preference for the shallow side. Tallarico and Farrell concluded that "the choice behavior of a chick on...a visual cliff is in part a function of the parameters of the prior-to-testing environment".

Kovach, Fabricius and Falt (1966) suggest that imprinting is actually a case of the organism forming its first percept. They studied the effect of imprinting on discrimination learning, reversed discrimination learning and avoidance learning and found that each type of learning was facilitated by having been imprinted to the stimulus (a flickering light with a rate of "four flicks per second") a month earlier at the age of 14 to 18 hours. The better performance of imprinted birds on reversed discrimination and avoidance learning is contrary to expectations if imprinting involves the acquisition of an irreversible approach response. Kovach et al. conclude that "it is possible that the long-range effects of imprinting are based neither on an irreversible attachment to the imprinting stimulus nor on a unique formation of a 'social bond'..., but on an acquisition process comparable to perceptual learning".

The facilitation found by Kovach et al. was characteristic only of those chicks that actually approached the stimulus while those that actively avoided the stimulus showed no such facilitation. It is possible that these latter chicks had already formed their first percept which prevented imprinting to flicker. This possibility is suggested by studies by Dimond (1966, 1968) in which he investigated the effect of pre-hatch photic stimulation on the development of fear in chicks. He found that chicks hatched from eggs incubated in darkness showed intense and persistent following and no avoidance of the imprinting

object (a red balloon), whereas, chicks hatched from light-incubated eggs moved away from the object as frequently as they approached it. Chicks were tested when 36 hours old (Dimond, 1966).

In a second study Dimond (1968) investigated the interaction of post-hatch visual stimulation with pre-hatch visual stimulation (unpatterned) and its relationship to fear responses. Three durations of post-hatch illumination, a) 15 minutes, b) six hours, and c) 12 hours while isolated in individual compartments were combined with two pre-hatch conditions, a) dark and b) illuminated by 60-watt bulb. Ss were otherwise kept in darkness and remained in darkness 24 hours before receiving post-hatch illumination treatment. Ss were tested at 36 hours old. It was found that light incubated Ss took longer to move from the position in which they were placed than did dark-reared Ss. This effect was found to be overcome by increasing periods of post-hatch illumination. Dark-incubated Ss followed the object significantly more than did light-incubated Ss, with both groups showing a decrease in following as duration of post-hatch illumination increased. The strongest effect was on gross avoidance responses, the light-incubated group showing significantly more avoidance.

The effect of pre-hatch patterned auditory stimulation on performance in a free choice situation was investigated by Grier, Counter and Shearer (1967). An experimental group of White Rock eggs was exposed to 200-hz tone presented at an on/off rate of 1.0/1.0

seconds. The tone was presented to the experimental group from day 12 to day 18. The Ss were tested on a 90 centimeter diameter table. Two speakers were mounted on opposite sides of the table. One speaker emitted the experimental 200-hz tone in the 1.0/1.0 seconds on/off pattern and the other emitted a novel stimulus of a 2000-hz tone at the same rate. The chick was placed in the center of the table and one speaker was turned on for 45 seconds. The distance the chick moved was recorded, the chick was returned to the center, and the other speaker was turned on for 45 seconds. The experimental group showed a preference for the 200-hz tone, while the attraction to the 2000-hz tone was the same for both controls and experimentals, and the controls showed no preference for either tone.

A second experiment tested the following response in the experimental group to a quiet model, a model emitting the novel 2000-hz tone and a model emitting the 200-hz tone. Out of a maximum possible of 30 seconds the time following was 5.35 seconds, 10.07 seconds, and 15.21 seconds respectively .

The perceptual model of behavior in the imprinting situation seems to be well supported by the studies reported in this section. In the imprinting situation perceptual familiarity whether pre-hatch or post-hatch results in a more vigorous positive response to the imprinting object. In free choice situations perceptual familiarity, whether pre-hatch or post-hatch, results in a preference for the

perceptually familiar stimulus.

In most of these studies the effect of the age of the S is not considered. When the effect of age is reported the usual critical period relationship is in evidence. The explanation of the decrease in responding after the critical period is given in terms of the perceptual model as being due to a progressive interference of the fear response (withdrawal) as the S develops an increasingly well defined standard of the perceptually familiar.

Perceptual Preference and Imprinting

Many studies have attempted to define optimal values for various parameters of the stimuli to which imprinting occurs. James (1959) investigated flicker rate of a visual stimulus. Plymouth Rock chicks were obtained from a commercial hatchery and held in individual compartments in an illuminated brooder and were tested at 48 hours in a 10 foot straight alley which admitted light from a 7.5-watt light through four holes arranged in a diamond pattern at each end of the alley. The trial lasted five minutes and the distance moved was recorded. No difference was found in the attractiveness of the three flicker patterns tested: 0.25/0.25 seconds, 1.0/1.0 seconds, or 5.0/5.0 seconds. Each pattern was tested against a constant light at the other end of the alley. Chicks were started in the center of the alley. Although James does not mention it, it is clear from the results reported that none of the groups preferred the constant light, i.e., all

chicks preferred some flicker to no flicker in spite of being held in constant illumination for 25 hours prior to testing. James does report that there was a significant difference in the "distributions of the scores in each of the three groups" but he does not report what form this significant difference takes. Repeated trials on successive days showed that the attractiveness of the flicker light increased steadily.

James (1960) also investigated the critical period hypothesis for the attractiveness of visual flicker. Chicks were obtained from a commercial hatchery and housed in individual compartments in a brooder. Chicks were introduced to an alley when 24 hours old. The alley was 10 feet long, two feet wide and 2.5 feet high and admitted light at each end from a 100-watt bulb through 0.75 inch diameter holes six inches high from the floor. A piece of clear polythene was interposed between the light and the hole. A blue two inch beaker hung upside down so that its bottom edge was just above the top of the hole in the end of the runway. The beaker could be moved from one end of the alley to the other. Chicks were exposed to either a slow rate of flicker, 5.0/0.2 seconds on/off or to a fast rate of flicker, 0.2/0.2 seconds on/off at the end of the alley at which the beaker was located while the light at the other end was constant. Chicks were either exposed to this condition at 24 hours of age or at six days of age. The chicks whose exposure to flicker was delayed until six days were exposed to constant light at both ends of the alley for the first five days.

Each training trial lasted five minutes. All chicks were tested after five training trials and after 10 training trials they were given another five test trials. During a test trial both lights were constant and the beaker was pulled from one end of the alley to the other at a rate of one foot in two seconds for a distance of two feet followed by 26 seconds stationary. This was repeated until the beaker was moved down the alley and back to within two feet of where it started.

Movement of the beaker began 30 seconds after the S was placed in the center of the alley, thus the test trial took about five minutes. The S's position was rated every 30 seconds and was scored as an 'approach' or as an 'avoidance' depending on whether the S was closer or farther from the beaker after the 30 seconds than he was before the 30 seconds. If the difference was less than three inches the S was scored as 'stationary'. On training trials remaining within three inches of the end at which the light was flickering was scored as an approach.

The measure of the effectiveness of flicker was the ratio of the difference between the approach and avoidance scores (taken as percentages of the maximum possible score) to the sum of the approach and avoidance scores. Using this measure flicker was found to be more effective for the younger Ss and the fast rate of flicker was found to be more effective than the slow rate of flicker.

Optimal values of parameters of various other stimuli to which imprinting occurs have also been studied. (Colour and form, Hess, 1959a; intermittent stimuli, Smith & Bird, 1963a; parental calls, Gottlieb, 1965.) Other studies have attempted to define such values for the stimuli that elicit approach. (Brightness and colour of flickering light, vertical and horizontal movement, diameter of stimulus, angle of regard, Smith & Hoyes, 1961; conspicuousness of stimuli, Bateson, 1964b.)

In Smith and Hoyes' study of brightness and colour of flickering lights chicks were housed in the dark in individual compartments and were tested 18 to 30 hours post-hatch. Chicks were tested in a four foot six inch run with a 12 by 12 inch aperture in one end covered by a white paper screen. Light from a projection lantern was focused on a six inch diameter disc at an on/off rate of 0.5/0.5 seconds. The bright disc read 0.36 foot-candles on a barrier layer cell and photometer, and a neutral filter reduced the intensity to 0.002 foot-candles for the 'dull' disc. It was found that the chicks showed a definite preference for the 'bright' disc. In a subsequent study filters were inserted so that red, green or white light could be presented under the same conditions as above. No difference in preference was found.

A series of experiments by Klopfler (1967) on preference for models painted a variety of colours or patterns led him to conclude that

"...models presumably can be ordered along a continuum from those to which imprinting simply can not occur through those to which imprinting can occur with equal ease, to those for which an immanent preference exists the expression of which is tied to the imprinting experience." (Klopfler, 1967)

Interaction Between Perceptual Familiarity and Perceptual Preference

Salzen (1962) found that although familiarity with the rearing environment lead to fear response when exposed to the imprinting situation, it did not prevent imprinting. This lead him to conclude that imprinting is a special type of familiarity related to the dynamic rather than the static environment.

Bateson (1964b), however, found that a 'conspicuous' static environment interferes more with imprinting to a moving model than does an 'inconspicuous' static environment. This indicates that imprinting is not a special type of perceptual familiarity but rather is a function of the nature of the perceptual stimulus, i.e., imprinting can occur strongly to a 'conspicuous' environment and thus interfere more with a subsequent attempt to imprint to a moving model than a similar previous experience with an 'inconspicuous' stimulus. Similar results were found by Klopfler (1965). He found that in a free choice situation chicks preferred a brightly coloured model more than a plain model regardless of which model they had previously been imprinted to. In this case perceptual familiarity with a plain model was not sufficient to overcome the innate preference for the coloured model.

Gottlieb (1965) found that four to 12 hours of perceptual familiarization with the call of the chicken or Wood duck did not diminish the preference of Peking ducklings for the call of their species. Another experiment demonstrated that briefly following a model emitting the Wood duck call lead to a preference for it over a chicken call but not over a parental call. A final experiment demonstrated that increasing the amount of active experience with the Wood duck call to four 20 minute exposures prior to testing resulted in a majority of ducklings choosing that call over the parental call.

These studies suggest that the effect of perceptual familiarity depends on the S's innate attitude toward the stimulus. If the S has an innate preference for the stimulus, then a brief familiarization with it will interfere strongly with a subsequent attempt to imprint the S to another stimulus. If, however, the stimulus is innately non-preferred it will require a more extended period of familiarization to result in the same amount of interference with a subsequent attempt to imprint the S.

The Present Experiment

The present experiment seeks to further define the effects of physiological age, pre-hatch perceptual familiarity, and innate perceptual preference on the approach response to visual flicker in the 'imprinting' situation.

The following hypotheses were considered:

1: The Innate Preference Hypothesis

James (1959) established that Plymouth Rock chicks preferred a flicker rate of 0.2/0.2 seconds on/off to a flicker rate of 5.0/0.2 seconds on/off. The present experiment sought to establish whether a similar innate preference is characteristic of Leghorn chicks. The preference among flicker rates of 0.2/0.2, 2.8/0.2, 3.8/0.2, and 4.8/0.2 seconds on/off and constant light was investigated and compared to the general activity level in a darkened alley.

2. The Maturational Hypothesis

The maturational model shown in Figure 1 predicts that the vigour of the approach response will be curvilinearly related to the age of the S with a peak in responding occurring when the development of locomotor ability is high and the development of fear is low. The model conceives of fearfulness as following a rigid course of development from low fearfulness to high fearfulness and does not consider any effect of pre-hatch exposure.

3: The Perceptual Hypothesis

The perceptual model shown in Figure 2 conceives of imprinting as perceptual learning and therefore predicts that pre-hatch familiarity will result in an increase in the vigour of the response to the familiar stimulus. Since the model conceives of fear as being a response to the unfamiliar rather than a function of physiological developmental level it does not predict that the response of the S will be related to the age of the S, per se.

Method

Experimental Design

The experimental design was as shown in Table 1. The eight cells of the design containing Ss receiving no pre-hatch exposure to visual flicker provided data on the innate perceptual preference of chicks and the 32 cells of the design containing Ss tested with either the 0.2/0.2 or the 2.8/0.2 seconds on/off flicker rate provided data on the effect of pre-hatch exposure. The data in all cells was utilized to determine the effect of the age of the S.

Subjects

The subjects were 469 Leghorn chicks. These were chicks that hatched and were in good condition at testing time. The chicks were hatched from 720 eggs obtained from the University of Alberta farm and incubated under the appropriate experimental conditions described below.

Incubation and Pre-exposure

Apparatus

Eggs were incubated in a model 50 Humidaire forced air incubator for 20 days. Each of three egg trays held 120 eggs in eight rows of 15 in depressions formed in 0.50 inch wire screen. The wire screen was used since it would not interfere with the circulation of air.

Table 1
Number of Subjects Assigned to Each Experimental Condition

		Testing Condition (Seconds on/off)						
Tray	Pre-hatch Exposure Condition (Sec. on/off)	Days of Pre-hatch Exposure	0.2/0.2	2.8/0.2	3.8/0.2	4.8/0.2	Constant	Dark
Top	0.2/0.2	1	18	18	-	-	-	-
		3	18	18	-	-	-	-
		7	18	18	-	-	-	-
	2.8/0.2	1	18	18	-	-	-	-
		3	18	18	-	-	-	-
		7	18	18	-	-	-	-
Middle	0.2/0.2	0	36	36	36	36	-	-
	2.8/0.2	0	36	36	-	-	36	36
Bottom	0.2/0.2	1	18	18	-	-	-	-
		3	18	18	-	-	-	-
		7	18	18	-	-	-	-
	2.8/0.2	1	18	18	-	-	-	-
		3	18	18	-	-	-	-
		7	18	18	-	-	-	-

During exposure of the experimental groups to visual flicker the, then empty, center egg tray (see Procedure below) was removed and a 2.75 inch outside diameter glass tube containing two 40-watt lumeline incandescent bulbs was inserted through holes in the side walls of the incubator. These holes were located centrally between the top and bottom tray. The holes were kept covered when the center tray was being used to hold eggs. A small fan mounted at the left end of the glass tube blew air over the bulbs which carried away excessive heat.

The flicker rates of the light sources were controlled by Hunter interval timers and during pre-exposure the incubator lights were turned on at 1:00 AM and off at 1:00 PM by an Inter-matic (T109) 24 hour clock switch.

Procedure

Throughout the entire experiment the temperature of the incubator was maintained as closely as possible to 99.5 degrees Fahrenheit and the humidity was maintained at a wet bulb reading of 85 to 86 degrees Fahrenheit. The incubator was rotated through a 90 degree turn at 9:30 AM, 1:30 PM and 5:30 PM each day during incubation. Temperature and humidity were recorded at these times and necessary adjustments were made.

Five groups of six dozen eggs each were set at intervals of 3, 6, 8, and 12 days at 1:30 PM.

In the incubator, 60 eggs of the first group were set in the forward four rows of 15 holders on the center tray. Eight additional eggs were set in the right hand, fifteenth position of the eight rows of the top tray and four additional eggs were set in the left hand, first position of the forward four rows of the top tray. (The odd placement of the extra dozen eggs in the first group, and a similar odd placement of an extra dozen in the second group was due to the necessity of placing five equal sized groups of eggs on three trays under the constraint that none of the eggs from the last three groups could be placed on the center tray. This constraint was necessary since the last three groups were to receive pre-exposure to visual flicker and therefore could not be on the center tray since this tray must be removed and replaced by the glass tube containing the lights during the period of pre-exposure.)

Sixty eggs of the second group were set in the rear four rows of 15 holders on the center tray. Eight additional eggs were set in the right hand, fifteenth position of the eight rows of the bottom tray and four additional eggs were set in the left hand, first position of the forward four rows of the bottom tray.

Thirty eggs of the third group were set in the left third of the top tray and the remaining 30 eggs were set in the left third of the bottom tray.

Thirty eggs of the fourth group were set in the middle third of the top tray and the remaining 30 eggs were set in the middle of the bottom tray.

Thirty eggs of the fifth group were placed in the right third of the top tray and the remaining 30 eggs were placed in the right third of the bottom tray. The locations of the eggs in each group is given in Table 2.

Each group of six dozen eggs was removed from the incubator at 1:30 PM after 20 days of incubation. After the first two groups were removed from the incubator, the center tray was removed and the lights were inserted and turned on to expose group three during day 20 of incubation, group four during day 18 to day 20, and group five during day 14 to day 20. Thus groups one and two were exposed to light zero days, group three was exposed one day, group four was exposed three days, and group five was exposed seven days. One 'day' of exposure consisted of exposure to flicker from 1:00 AM to 1:00 PM followed by darkness from 1:00 PM to 1:00 AM the following morning.

This procedure was carried out first using a flicker rate of 0.2/0.2 seconds on/off. The entire procedure was repeated the next month using a flicker rate of 2.8/0.2 seconds on/off.

Table 3 shows the intensity of the pre-exposure light over the surface of the eggs on the top tray and Table 4 shows the corresponding intensities for the bottom tray. The effect of flicker on the intensity of the light is shown in Table 5 and the effect of an interposing egg shell is shown in Table 6. A visual spectrum characterization of the light source is given in Table 7.

Table 2

Location of Eggs in the Five Experimental Groups

		Position														
Tray	Row	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Top	1	3	3	3	3	3	4	4	4	4	5	5	5	5	5	1
	2	3	3	3	3	3	4	4	4	4	5	5	5	5	5	1
	3	3	3	3	3	3	4	4	4	4	5	5	5	5	5	1
	4	3	3	3	3	3	4	4	4	4	5	5	5	5	5	1
	5	1	3	3	3	3	4	4	4	4	4	5	5	5	5	1
	6	1	3	3	3	3	4	4	4	4	4	5	5	5	5	1
	7	1	3	3	3	3	4	4	4	4	4	5	5	5	5	1
	8	1	3	3	3	3	4	4	4	4	4	5	5	5	5	1
Middle	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bottom	1	3	3	3	3	3	4	4	4	4	5	5	5	5	5	2
	2	3	3	3	3	3	4	4	4	4	5	5	5	5	5	2
	3	3	3	3	3	3	4	4	4	4	5	5	5	5	5	2
	4	3	3	3	3	3	4	4	4	4	5	5	5	5	5	2
	5	2	3	3	3	3	4	4	4	4	4	5	5	5	5	2
	6	2	3	3	3	3	4	4	4	4	4	5	5	5	5	2
	7	2	3	3	3	3	4	4	4	4	4	5	5	5	5	2
	8	2	3	3	3	3	4	4	4	4	4	5	5	5	5	2

Table 3

Intensity of Light ($\mu w \text{ cm}^{-2} \text{ m}\mu^{-1}$) at 25 Positions on the Bottom
of the Top Tray (Measured for constant light at 750 m μ)

Inches from Left Edge of Egg Tray					
Inches from Rear Edge of Egg Tray	2.25	7.75	13.25	18.75	24.25
1.25	0.178	0.154	0.175	0.178	0.186
4.50	0.245	0.258	0.227	0.245	0.219
7.75	20.010	23.700	0.743	24.300	23.200
11.00	0.160	0.194	0.262	0.194	0.186
14.25	0.130	0.178	0.182	0.164	0.178

Table 4

Intensity of Light ($\mu w \text{ cm}^{-2} \text{ m}\mu^{-1}$) at 25 Positions Two Inches
Above the Bottom of the Bottom Tray (Measured for
constant light at 750 m μ)

Inches from Left Edge of Egg Tray					
Inches from Rear Edge of Egg Tray	2.25	7.75	13.25	18.75	24.25
1.25	0.489	0.606	0.660	0.650	0.535
4.50	0.470	0.567	0.648	0.660	0.535
7.75	16.200	17.000	10.050	18.600	14.780
11.00	0.467	0.616	0.680	0.729	0.592
14.25	0.635	0.632	0.645	0.662	0.543

Table 5

Effect of Flicker Rate on Intensity of Light for Five Representative
 Values of Constant Light ($\mu w \text{ cm}^{-2} \text{ m}\mu^{-1}$ at 750 $\text{m}\mu$)

Constant	0.2/0.2	Decreases to During Off Pulse (2.8/0.2)
16.200	7.540	12.630
0.745	0.348	0.584
0.632	0.300	0.502
0.243	0.113	0.194
0.162	0.079	0.125

Table 6

Effect of Filtering Light Through an Egg Shell on Five Representative
 Values of Constant Light ($\mu w \text{ cm}^{-2} \text{ m}\mu^{-1}$ at 750 $\text{m}\mu$)

No Egg Shell	Egg Shell			Average Effect
	1	2	3	
16.200	2.020	1.860	1.990	1.960
0.745	1.580	1.510	1.620	1.570
0.632	1.020	0.955	1.040	1.010
0.243	0.450	0.431	0.454	0.445
0.162	0.405	0.364	0.405	0.391

Table 7

Visible Spectrum Characterization of Light Source at Four Intensities

$$(\mu w \text{ cm}^{-2} \text{ m}\mu^{-1})$$

Wave Length (mμ)								
750	700	650	600	550	500	450	400	380
0.178	0.127	0.074	0.044	0.018	0.006	-----	-----	-----
0.535	0.400	0.234	0.136	0.089	0.034	0.008	-----	-----
14.780	14.220	11.310	8.960	8.600	4.860	1.880	0.944	0.813
23.200	23.250	17.500	15.390	15.200	8.630	3.380	1.690	1.540

HatchingApparatus

Eggs were hatched in two 0.375 inch plywood hatchers. The internal dimensions of each hatcher were 32 inches long, 24 inches wide and 22 inches deep. Heat was supplied by two 150-watt strap heaters located in the bottom of the hatcher and air was circulated by a small fan with a four inch blade also located in the bottom of the hatcher. A shallow tray with a capacity of two gallons was mounted six inches from the bottom of the hatcher. This tray was filled with water daily to maintain a wet bulb humidity reading of approximately 95 degrees Farenheit. A heavy 0.25 inch wire screen was mounted 12 inches from the bottom of the hatcher. This screen served as the bottoms for the 48 individual four by four inch compartments located above the screen in six rows of eight compartments each. The screen

allowed free air circulation through the compartments. When in use the first and last compartments in each row were not utilized, thus the capacity of each hatcher was three dozen eggs. Together the two hatchers provided the required capacity of six dozen eggs. Each compartment was six inches deep thus leaving four inches of free circulation above the compartments. The top of the hatcher was divided into 48 independent sections providing individual access to each compartment. Temperature was maintained at approximately 99.5 degrees Fahrenheit by a wafer thermostat located on the wall of the hatcher below the individual compartments and above the water tray.

Procedure

After 20 days of incubation the six dozen eggs in a group were transferred to the hatchers. For each group of eggs, one-half of the eggs from the top tray were put in one hatcher and the remaining half of the eggs were placed in the other hatcher. The eggs from the center and bottom trays were similarly treated. This assured that any difference in the hatchers would not bias the results for any group.

The eggs were placed in the hatcher at 1:30 PM and the time of hatch to the nearest two hours was established for each chick by checking every two hours for the next 48 hours. Checking was accomplished in the dark by removing the door to the compartment and feeling by hand for either the egg or the shell. If the egg was hatched the shell was removed and placed on top of the door to the compartment.

These compartments were not opened again during subsequent checks, thus a chick was only disturbed once after hatching. When the check was completed the light in the room was turned on and the positions of the chicks hatched during that period were recorded then the light was turned off again.

Testing

Apparatus

Ss were tested in one of 18 identical alleys. The alleys were held on a three shelled rack. Each shelf held six alleys. The alleys were 18 inches apart on the shelf and the shelves were 24 inches apart. The internal dimensions of each alley were 20 inches long, 3.5 inches wide and 7.75 inches deep. Light was admitted through a one inch diameter hole located in the center of one end 3.75 inches from the top of the alley. Half of a Leghorn egg shell was glued into the hole providing a filter to reduce the intensity of the light to approximate pre-hatch intensities of exposure. The egg shell was secured with the unbroken end seated in the hole and the broken end pointing toward the light source. The light source was a 12 inch Westinghouse 40-watt lumeline tubular bulb, the same as was used for pre-exposure in the incubator. The light was centrally located in a box with internal dimensions of 3.5 inches wide, 3.5 inches long and 13 inches deep. Light was emitted from the box through a one inch diameter hole located in alignment with the hole in the end of the alley and at a distance of two inches from it.

The light was isolated from the alley by the two inch gap in order to prevent the alley from becoming heated by the light source.

The intensity of the light at the point of admission to the alleys is given in Table 8 and the intensity in the start boxes of the alleys is given in Table 9.

The floor of the alley consisted of a teeter-totter mounted on a brass rod pivot 0.5 inches from the bottom of the alley and 9.5 inches from the back wall of the start box, hence 10.5 inches from the end wall through which the light was admitted. A 0.5 inch stop located under the teeter-totter at the start box end prevented depression of the floor at that end. A micro-switch was located under the teeter-totter at the opposite end of the alley. For each alley the spring in the micro-switch was adjusted so that a weight of 45 grams, the approximate weight of a 24 hour old chick, located three inches beyond the pivot would cause the micro-switch to close. The start box was five inches long and separated from the rest of the alley by a sliding door. Each alley was equipped with a push button switch which could by-pass the micro-switch and activate a kymograph. This switch was used to record the time at which the sliding door of the start box was raised. Each alley had two four inch doors, one at either end of the roof of the alley through which the chicks were admitted to and removed from the alley. The alleys were made of 0.375 inch plywood throughout except for the teeter-totter floor which was made of 0.25 inch tempered masonite since this material is resistant to warping.

Table 8

Intensity of Light at Point of Admission for Each of the 18 Alleys

(Intensity measured for constant light at 750 mμ by spectroradiometer
in units of $\mu\text{w cm}^{-2} \text{ m}\mu^{-1}$ using optical probe)

Position						
Shelf	1	2	3	4	5	6
1	0.314	0.313	0.235	0.201	0.288	0.308
2	0.266	0.292	0.264	0.316	0.326	0.369
3	0.311	0.266	0.300	0.284	0.313	0.290

Table 9

Intensity of Light at Door of Start Box for Each of the 18 Alleys

(Intensity measured for constant light at 750 mμ by spectroradiometer
in units of $\mu\text{w cm}^{-2} \text{ m}\mu^{-1}$ using optical probe)

Position						
Shelf	1	2	3	4	5	6
1	0.008	0.008	0.007	0.005	0.008	0.008
2	0.008	0.008	0.008	0.008	0.008	0.009
3	0.008	0.008	0.008	0.008	0.008	0.008

The time taken to move down the alley close enough to the light source to cause depression of the teeter-totter floor was recorded on a 20 pen Esterline Angus kymograph.

Procedure

Ss were tested at 1:30 PM, 3:30 PM or 5:30 PM. An effort was made to match the age distribution of Ss under each testing condition. The Ss were placed in the alleys and after the last S was placed in it's alley, the experimenter began to raise the doors of the start boxes. The order in which tests were begun was the same as the order in which Ss were placed in the alleys. This was done in order to make the time spent in the alley before the test began approximately the same for all Ss. The start was alternated between chicks under the 0.2/0.2 seconds on/off flicker rate test condition and chicks under the 2.8/0.2 seconds on/off flicker rate test condition. This was done in order to make the average time at which the two test groups began approximately the same. The start times were recorded on the kymograph by momentarily closing the circuit to the pen while raising the door of the alley. The testing period lasted 75 minutes. This duration was long enough to elicit a response from most Ss. After the test the Ss were removed from the alleys and taken to a lighted room in order to check for crippling. The record of any S that was crippled so badly that he could not walk was eliminated from his group.

The hatching and testing procedure was repeated for the five test groups that had been pre-exposed to the 0.2/0.2 seconds on/off

flicker rate. The following month the entire procedure was repeated this time pre-exposing the eggs to a 2.8/0.2 seconds on/off flicker rate. Each month the first unexposed group was used to evaluate the response of the chicks to testing conditions other than the 0.2/0.2 seconds and 2.8/0.2 seconds on/off flicker rates. The first month the response of the chicks to a 3.8/0.2 seconds on/off flicker rate and a 4.8/0.2 seconds on/off flicker rate was evaluated. The following month the response of the chicks to constant light and to total darkness was evaluated.

General Conditions

The entire experiment was carried out in a dark room except for the brief exception noted above. The temperature of the room was maintained at approximately 85 to 90 degrees Fahrenheit by steam pipes passing through the room. Throughout the entire experiment noise and calls made by the chicks were masked by white noise. Representative readings of white noise intensity are given in Table 10.

Table 10

White Noise Intensity Inside and Outside of the Experimental Apparatus

Apparatus	Noise Level	Noise Level
	Inside (decibels)	Outside (decibels)
Incubator	78	86
Top left alley	74	87
Top right alley	76	87
Bottom left alley	78	93
Bottom right alley	79	89
Hatchers	80	95

Results

Analyses

The age of the Ss at the time of test in terms of hours since hatching was determined by subtracting the time at which the S hatched from the time at which the S was tested. This information was utilized to increase the precision of the experiment through the use of analysis of covariance. A statistical control over the effect of the age of the Ss at the time of test was necessary since this variable was not directly controlled by E.

The average age of the Ss in each cell is given in Appendix A.

A preliminary examination of the effect of the age of the S revealed that the curvilinear relationship characteristic of the critical period was in evidence. Both the age of S and the square of the age of S were therefore included as covariates in the analysis of covariance in order to adjust for the curvilinear dependence of the vigour of the response on the age of the S.

Since the number of Ss per cell was unequal due to infertility, death and crippling, an unweighted means approach was used in these analyses (Winer, 1962).

Examination of the within cells distribution of response times revealed that these distributions were markedly skewed with most response times below the mean. A reciprocal transformation resulted in a more normal within cells distribution. All analyses were carried

Table 11
Number of Subjects Tested Under Each Experimental Condition

		Testing Condition (Seconds on/off)						
Tray	Pre-hatch Exposure Condition (Sec. on/off)	Days of Pre-hatch Exposure	0.2/0.2	2.8/0.2	3.8/0.2	4.8/0.2	Constant	Dark
Top	0.2/0.2	1	14	10	-	-	-	-
		3	11	13	-	-	-	-
		7	12	13	-	-	-	-
	2.8/0.2	1	11	13	-	-	-	-
		3	12	11	-	-	-	-
		7	14	12	-	-	-	-
Middle	0.2/0.2	0	23	19	26	27	-	-
		0	19	23	-	-	23	22
	0.2/0.2	1	11	8	-	-	-	-
		3	14	14	-	-	-	-
		7	12	13	-	-	-	-
	2.8/0.2	1	10	10	-	-	-	-
		3	12	13	-	-	-	-
		7	13	11	-	-	-	-

out on these transformed data, i. e. , on response speeds (alley length/minute).

Number of Subjects Tested

Of the 720 eggs set, approximately 70% hatched, indicating that incubation and hatching conditions were somewhat less than ideal. Under ideal conditions a hatchability of 90% can be attained for Leghorns.

A further loss of 5% of the Ss was experienced due to crippling. Data was collected on the remaining 65% of the Ss that had hatched and were in good condition at the time of testing. The number of Ss tested under each experimental condition is given in Table 11.

The Effect of Age of Subject

The pooled within cells regression of response speed on the age of the S and on the square of the age of the S was calculated using the data from all Ss. The results of the regression analysis are given in Table 12.

The quadratic regression of response speeds on the covariates was significant at $p < .01$. This shows that adjusting for the critical period relationship will result in a significant improvement in the precision of the analysis.

Table 12

Regression of Response Speeds on Covariates

Source	SS	df	MS	F
Regression	0.621	2	0.311	7.035 **
Residual	19.201	435	0.044	

** $p < .01$

The residual was then subdivided into a component S1 due to the variation around the within cells regression coefficients and a component S2 due to the variation of the within cells regression coefficients around the pooled within cells regression coefficients. The assumption of homogeneity of within cells regression on which the analysis of covariance depends was then checked by computing the F ratio of the S2 mean square to the S1 mean square. The results of this analysis are given in Table 13.

Table 13

Homogeneity of Regression

Source	SS	df	MS	F
S2	2.484	62	0.040	0.894
S1	16.717	373	0.045	

The variation in the within cells regression coefficients was not significant. This indicates that the critical period relationship between speed of response and age of S holds regardless of any effect of pre-hatch exposure.

The regression coefficient of response speed on the age of S was 0.01406. The regression coefficient of response speed on the square of the age of the S was -0.00034. Using these coefficients and the mean response speed, 0.132; mean age, 26.245; and mean age squared, 754.501, the predicted response speeds over the ages 11 to 41 hours were calculated. A plot of the resulting values is shown in Figure 3. The predicted response speed, Y, was calculated using the regression equation:

$$Y = 0.132 + 0.01401 \times (X - 26.245) - 0.00034 \times (X^2 - 754.501).$$

The index of correlation for these predicted response speeds with the actual response speeds was 0.177.

Innate Preference

The data from all Ss receiving no pre-exposure to visual flicker were analyzed first by a one-way analysis of covariance with the age of S and the square of the age of S as covariates. In this analysis there were eight levels of flicker with levels, 0.2/0.2 and 2.8/0.2 seconds on/off being each represented twice. One set of data for these flicker rates was collected during the first month when pre-exposure to the 0.2/0.2 seconds on/off flicker rate was being carried out.

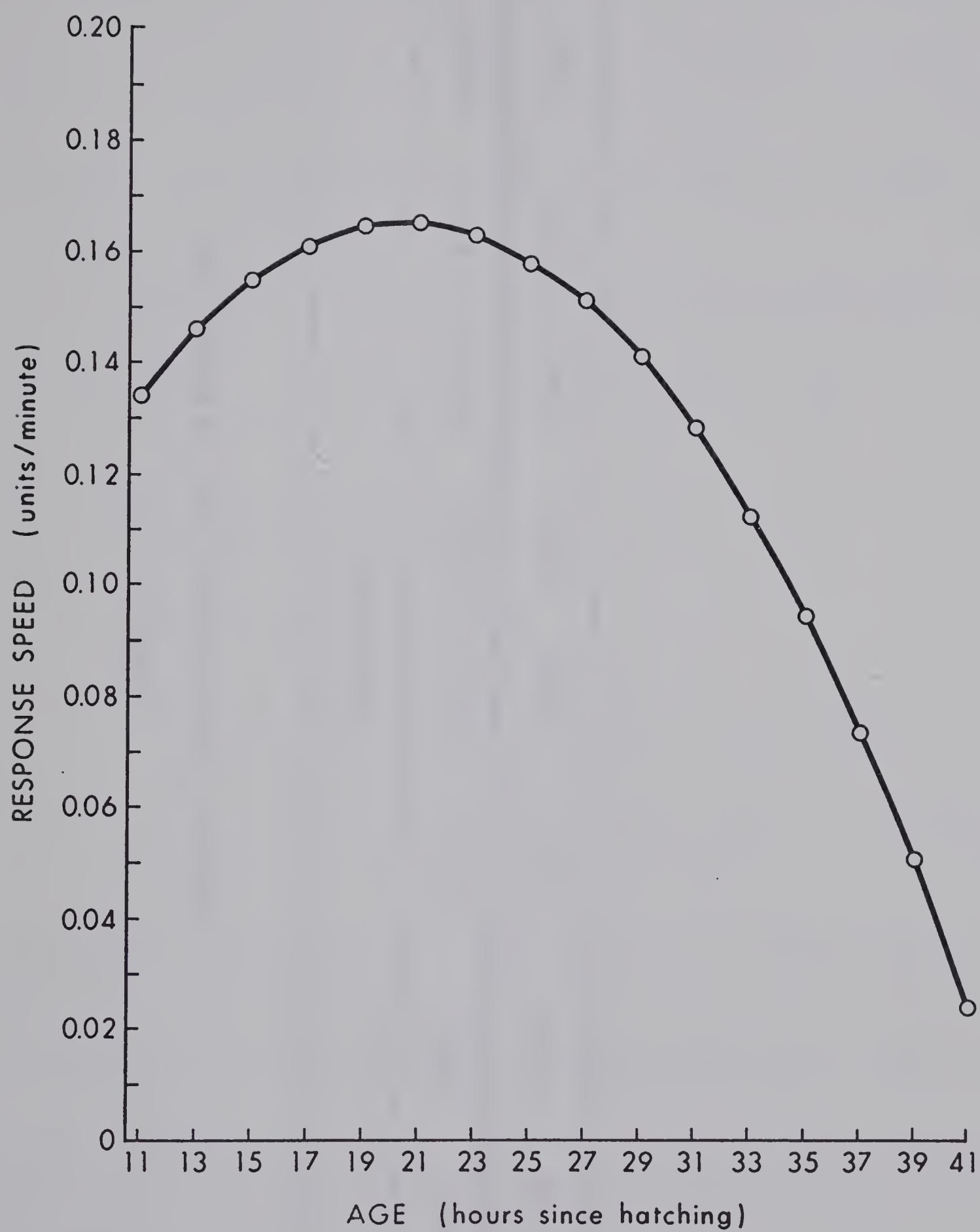


Figure 3. Response speed as a function of age.

Table 14
Adjusted Means for Eight Levels of Flicker Rate

Flicker Rate							
Dark	0.2/0.2	0.2/0.2	2.8/0.2	2.8/0.2	3.8/0.2	4.8/0.2	Constant
0.128	0.132	0.106	0.088	0.090	0.094	0.051	0.044

The adjusted means of these cells were used to evaluate the adequacy of control over incubation, hatching and testing conditions to ensure that these conditions were the same during the second month as during the first month. The adjusted means for the eight levels of flicker rate are given in Table 14.

The adjusted means, \bar{Y}_a , were calculated using the regression equation: $\bar{Y}_a = \bar{Y} - b_{yx} \times (\bar{X} - XM) - b_{yz} \times (\bar{Z} - ZM)$, where

\bar{Y} = cell mean response speed

\bar{X} = cell mean age

\bar{Z} = cell mean age squared

XM = over all mean age

ZM = over all mean age squared

b_{yx} = regression coefficient of response speed on age

b_{yz} = regression coefficient of response speed on age squared

No significant differences were found for the controls between results obtained during the first month and results obtained during the second month. The data obtained for the flicker rates were therefore combined and a one-way analysis of covariance with six levels of flicker rate was carried out. The results of the analysis are given in Table 15 and the adjusted means for the six levels of flicker are given in Table 16.

Table 15

Analysis of Covariance for Effect of Flicker Rate

Source	SS	df	MS	F
Between	0.216	5	0.043	3.289 **
Covs	0.087	2	0.044	3.289 *
Error	2.282	174	0.013	

** $p < .01$ * $p < .05$

Table 16

Adjusted Means for Six Levels of Flicker Rate

(Including Dark Control)

Flicker Rate					
Dark	0.2/0.2	2.8/0.2	3.8/0.2	4.8/0.2	Constant
0.129	0.120	0.089	0.093	0.050	0.044

The adjusted means show that there is a linear trend of speed of response over flicker rate with fast flicker rates being more preferred, slow flicker rates being less preferred, and constant light being least preferred. This linear trend was significant at $p < .01$.

The results of the analysis of the linear trend are given in Table 17.

Table 17

Linear Trend Over the Five Levels of Flicker Rate

Source	SS	df	MS	F
Linear trend	0.111	1	0.111	8.463 **
Error	2.282	174	0.013	

** $p < .01$

There was no significant difference between response speed for the most preferred stimulus and response speed for the control condition obtained in a totally darkened alley. Response speed to the least preferred stimulus, constant light, was significantly lower than response speed in a totally darkened alley ($p < .01$).

The Effect of Pre-hatch Perceptual Familiarity

All Ss tested with either the 0.2/0.2 or the 2.8/0.2 seconds on/off flicker rates were analyzed by a $2 \times 2 \times 2 \times 3$ analysis of covariance with two control groups. The first control group contained all Ss receiving no pre-exposure and tested with the 0.2/0.2 seconds on/off flicker rate. The second control group contained all Ss receiving no pre-exposure and tested with the 2.8/0.2 seconds on/off flicker rate.

For purposes of the analysis the pre-exposure condition was classified as being either the same as or different from the test stimulus. This classification of the pre-exposure condition was utilized since the perceptual model addresses itself directly to the effect of pre-exposure to the imprinting stimulus and only indirectly, through a consideration of generalization, to the effect of pre-exposure to another stimulus.

Since it was necessary due to the physical restrictions of the incubator to expose one-half of the eggs on a tray located above the light while the remaining half of the eggs were exposed on a tray located below the light, the tray on which the S received its pre-exposure was included in the analysis. No hypothesis as to the effect of this treatment was entertained.

The results of the analysis of covariance are given in Table 18. In this table the sources of variance are coded as follows:
A: Tray, Top vs. Bottom; B: Flicker Rate During Test, 0.2/0.2 vs. 2.8/0.2; C: Pre-exposure, Same vs. Different; D: Duration of Pre-Exposure, 1, 3, or 7 Days.

In general the 0.2/0.2 seconds on/off flicker rate was preferred to the 2.8/0.2 seconds on/off flicker rate (B main effect: $p < .01$). However, this differential response to flicker rate also depended both on the tray on which the S was pre-exposed (A x B interaction: $p < .01$) and on the nature of the pre-exposure, i.e., on

Table 18

Analysis of Covariance for Ss Receiving Pre-exposure to Visual Flicker

Source	SS	df	MS	F
A (Tray)	0.004	1	0.004	0.076
B (Test)	0.467	1	0.467	8.827 **
AB	0.354	1	0.354	6.699 **
C (Exposure)	0.068	1	0.068	1.294
AC	0.295	1	0.295	5.569 *
BC	0.237	1	0.237	4.474 *
ABC	0.002	1	0.002	0.047
D (Duration)	0.119	2	0.060	1.123
AD	0.173	2	0.087	1.636
BD	0.056	2	0.028	0.532
ABD	0.039	2	0.020	0.371
CD	0.434	2	0.217	4.103 *
ACD	0.403	2	0.202	3.816 *
BCD	0.217	2	0.109	2.053
ABCD	0.016	2	0.008	0.148
COVS	0.631	2	0.315	5.962 **
ERROR	18.139	343	0.053	

** $p < .01$ * $p < .05$

whether the pre-exposure was to the test stimulus or not (B x C interaction: $p < .05$).

The effect of pre-hatch exposure to the test stimulus depended significantly on the duration of that pre-exposure (C x D interaction: $p < .05$). The nature of that dependence however was further dependent on the tray on which the S was exposed (A x C x D interaction: $p < .05$). A graphic presentation of this interaction, using adjusted means, is given in Figure 4. For purposes of comparisons the adjusted means for the control groups are included in the figure as zero days of pre-exposure.

Figure 4 suggests that the nature of the interaction between the pre-exposure condition and the duration of pre-exposure shown by Ss receiving pre-exposure on the top tray differs in three distinctive ways from that shown by Ss receiving pre-exposure on the bottom tray. These differences are:

(1) For Ss pre-exposed to the test stimulus on the bottom tray the facilitation of response speed over that shown under the control condition shows a linear trend over duration of pre-exposure (1 to 7 days) with the greatest facilitation occurring after one day of pre-exposure.

For Ss pre-exposed to the test stimulus on the top tray the facilitation of response speed shows a quadratic trend over duration of pre-exposure (1 to 7 days) with the greatest facilitation occurring after three days of pre-exposure.

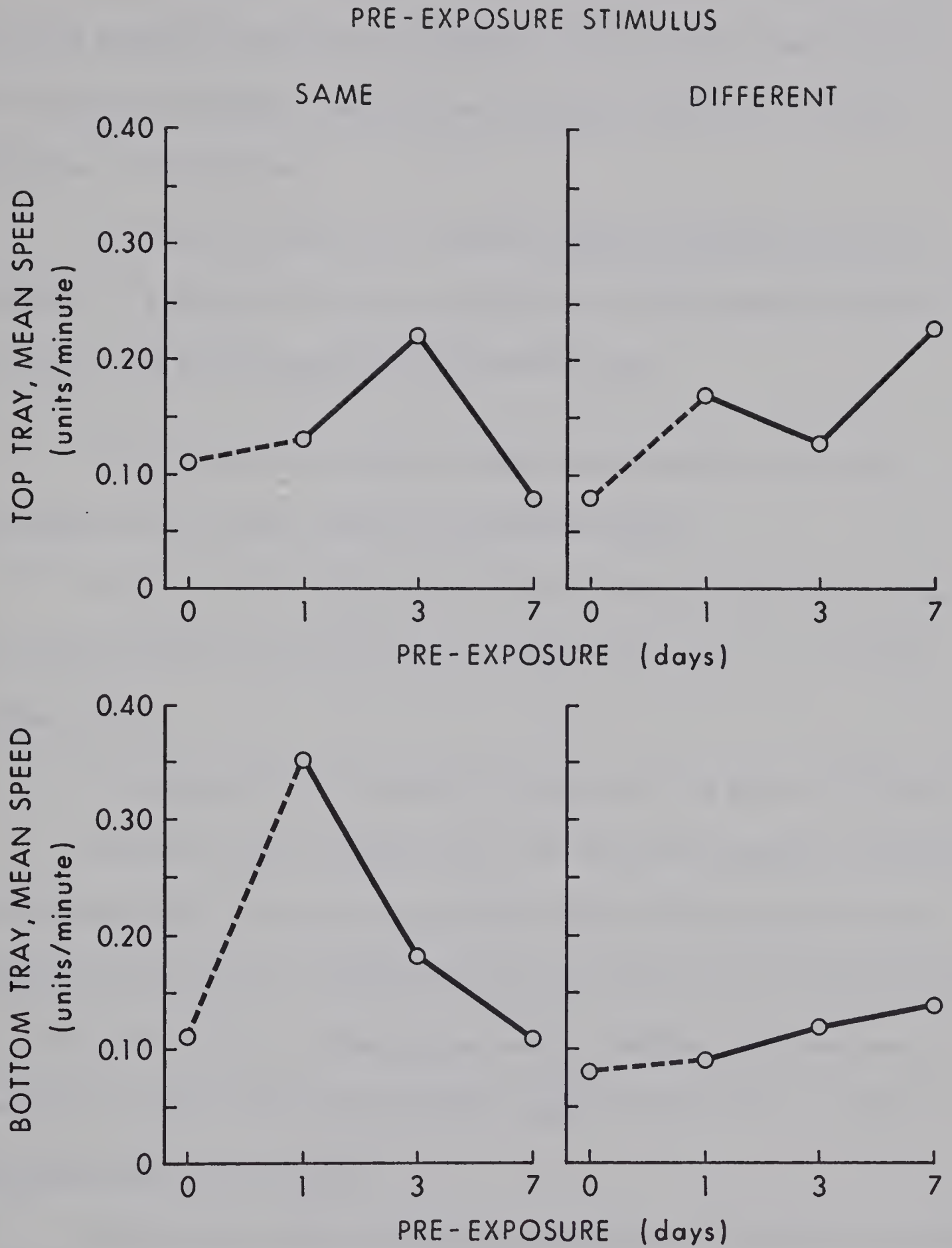


Figure 4. The effect of pre-exposure for each tray.

(2) For Ss pre-exposed to the test stimulus on the bottom tray the greatest facilitation of response speed is twice the greatest facilitation of response speed shown by Ss pre-exposed to the test stimulus on the top tray.

(3) The facilitation in response speed resulting from pre-exposure to a different stimulus is greater for Ss exposed on the top tray than it is for Ss exposed on the bottom tray.

The significance of these differences was determined by carrying out the further analyses considered below.

The two levels of the test stimulus did not significantly affect the nature of the interaction shown in Figure 4 (A x B x C x D interaction: N.S.).

The adjusted mean speeds for each cell are given in Table 19.

Since the effect of the tray on which S was exposed, the effect of the flicker rate during testing and the effect of the duration of pre-exposure all interacted significantly (A x B; B x C; D x C interactions: $p < .05$) with the effect of the pre-exposure condition, the analyses of covariance of the effects for each pre-exposure level (i.e., same or different) were carried out.

The results of the analysis of covariance of the effects for Ss receiving pre-exposure to the test stimulus are given in Table 20. In this table the sources of variance are coded as follows: A: Flicker Rate During Test; B: Tray, Top vs. Bottom; C: Duration of pre-exposure, 1, 3, or 7 Days.

Table 19

Adjusted Cell Mean Speed: units/minute

Tray	Testing Condition (Sec. on/off)	Pre-hatch Exposure Condition	Days of Pre-hatch Exposure			
			0	1	3	7
Top	0.2/0.2	Same	-	0.201	0.282	0.065
		Different	-	0.316	0.181	0.356
	2.8/0.2	Same	-	0.023	0.170	0.101
		Different	-	0.044	0.072	0.075
Middle	0.2/0.2		0.112	-	-	-
	2.8/0.2		0.084	-	-	-
Bottom	0.2/0.2	Same	-	0.355	0.166	0.049
		Different	-	0.108	0.139	0.203
	2.8/0.2	Same	-	0.350	0.195	0.161
		Different	-	0.080	0.111	0.059

Table 20

Analysis of Covariance of Effects of Pre-hatch Exposure to the Same
Stimulus

Source	SS	df	MS	F
A (Test)	0.012	1	0.012	0.233
B (Tray)	0.184	1	0.184	3.473
AB	0.149	1	0.149	2.824
C (Duration)	0.492	2	0.246	4.650 *
AC	0.162	2	0.081	1.531
BC	0.524	2	0.262	4.953 **
ABC	0.014	2	0.007	0.134
COVS	0.631	2	0.315	5.962 **
ERROR	18.139	343	0.053	

** $p < .01$

* $p < .05$

The effect of duration of pre-hatch exposure to the test stimulus was significant at $p < .05$. The nature of this effect for eggs exposed on the top tray was significantly different from the nature of the effect for eggs exposed on the bottom tray ($p < .01$). For eggs on the bottom tray the greatest facilitation of response speed occurred after one day of pre-exposure (See Figure 4). This facilitation

after one day of pre-exposure was significant at $p < .01$ by Dunnett's test for comparison of treatments with a control. The linear trend in the decrease in facilitation with days of pre-exposure was significant at $p < .01$.

For eggs on the top tray there was no significant facilitation of response speed after one day of pre-hatch exposure to the test stimulus. After three days of pre-exposure the facilitation was significant at $p < .05$ by Dunnett's test. This facilitation decreased after seven days of pre-exposure. The quadratic trend of response speed over days of pre-exposure was significant at $p < .05$.

The effect of pre-hatch exposure to the test stimulus did not depend significantly on the flicker rate of the stimulus.

The results of the analysis of covariance of effects for Ss receiving pre-exposure to a different flicker rate than the one used during the test are given in Table 21. In this table the sources of variation are coded as follows: A: Flicker Rate During Test, 0.2/0.2 vs. 2.8/0.2; B: Tray, Top vs. Bottom; C: Duration of Pre-exposure, 1, 3, or 7 Days.

For eggs pre-exposed to a different stimulus, most of the variance can be accounted for by a significant preference for the 0.2/0.2 seconds on/off flicker rate over the 2.8/0.2 seconds on/off flicker rate (A main effect: $p < .01$).

Table 21

Analysis of Covariance of Effects for Ss Receiving Pre-exposure to
a Different Stimulus

Source	SS	df	MS	F
A (Test)	0.671	1	0.671	12.695 **
B (Tray)	0.115	1	0.115	2.170
AB	0.208	1	0.208	3.933 *
C (Duration)	0.057	2	0.029	0.535
AC	0.119	2	0.060	1.124
BC	0.054	2	0.029	0.508
ABC	0.041	2	0.021	0.383
COVS	0.631	2	0.315	5.962 **
ERROR	18.139	343	0.053	

** $p < .01$

* $p < .05$

This preference, however, is significantly dependent upon the tray on which the Ss received their pre-exposure (A x B interaction: $p < .05$). For Ss pre-exposed on the top tray the preference for the 0.2/0.2 seconds on/off flicker rate is greater than it is for Ss pre-exposed on the bottom tray.

The increase in preference for Ss exposed on the top tray is due to a significant facilitation of the speed of response to the 0.2/0.2 seconds on/off flicker rate after pre-exposure to the 2.8/0.2 seconds on/off flicker rate (Controls vs. 1 day: $p < .05$; vs. 3 days: N.S.; vs. 7 days: $p < .01$ by Dunnett's test). A similar tendency shown by Ss on the bottom tray was not significant.

Discussion

Innate Preference

The present experiment found that for Leghorn chicks fast flicker rates were most preferred, while slower flicker rates were less preferred and constant light was least preferred. These results agree with the results obtained by James (1959) in his investigation of the innate preference for flicker characteristic of Plymouth Rock chicks.

Comparing the S's response to the most preferred flicker rate with the S's behavior in a darkened alley revealed that the results obtained for the most preferred flicker rate could be accounted for by the S's activity level in a darkened alley. As the flicker rate of the stimulus decreased the activity of the S in the alley was progressively depressed below the normal activity level (See Table 16).

This variation in the S's innate attitude toward the stimuli from neutral to negative suggests that the use of the term 'preference' places too much emphasis on a positive attitude toward stimuli. It would perhaps be better to classify stimuli according to a scale of innate 'approachability' rather than according to a scale of innate 'preference'. This would result in no change in the order of the stimuli but would emphasize that a positive attitude toward a stimulus is often a result of imprinting rather than a condition for imprinting.

The Perceptual Hypothesis

In the present study the effect of perceptual familiarization was complicated by an interaction with the tray on which the S was exposed. No definite conclusion as to the reason for the importance of the tray on which the S received pre-exposure can be made since the trays differed in two important respects. The intensity of the pre-exposure light reaching the Ss on the top tray was considerably less than the intensity of the pre-exposure light reaching Ss on the bottom tray (See Table 3 and 4). In addition to this difference Ss on the top tray received their exposure to flicker from below while Ss on the bottom tray received their exposure from above.

The facilitation of response speed found in the present experiment after pre-exposure to the stimulus agrees with the previous findings discussed above. An increase in this facilitation, as found for Ss on the top tray, after a longer period of familiarization also agrees with previous findings. No previous experiment has found a decrease in facilitation resulting from a further increase in the period of familiarization.

Lack of support for this finding seems to be due at present primarily to a lack of investigation. Evaluation of the effect of post-hatch perceptual familiarization has usually been confined to short periods of familiarization in the order of hours rather than the long periods of familiarization over days used in the present experiment.

The single exception is that reported by Candland et al. (1963) in which Ss were familiarized with the stimuli over a period of 25 days. This period of familiarization resulted in Ss showing a preference for the familiar stimuli in a stress situation. No comparison was made, however, with the effect of a more brief period of familiarization.

Grier (1967) evaluated the effect of pre-hatch familiarization with an auditory stimulus and found that seven days of pre-exposure resulted in an increase in the preference for that stimulus. It was also the case in this investigation that no comparison with a more brief period of familiarization was made.

Further investigation is necessary to determine under what conditions this decrease in facilitation will occur. It will then be important to determine whether this effect must be considered as an effect of pre-hatch imprinting or whether it can be understood in the framework of a more general theory of boredom. If the effect can not be understood in a more general framework then the perceptual model must be altered to accommodate this effect.

The Maturation Hypothesis

The critical period relationship between the speed of response and the age of the S predicted by the maturational hypothesis was found in the present experiment (See Figure 3).

The brief increase in response speed with age shown initially by Ss can be attributed to the maturation of motor ability.

Previous authors have explained the decrease in response speed with age occurring after the peak as being due to the maturation of fear responses (Hess, 1959b) or as being due to perceptual learning (Broom, 1966).

In the context of the present experiment this relationship can not be explained in terms of perceptual learning. It could be argued that the older S is the longer S has become familiar with the characteristics of the hatcher in which S is held prior to testing, hence the more well defined is S's standard of the perceptually familiar and the greater is S's fear level on being transferred to the unfamiliar testing situation. The effect of this higher level of fear would however be dependent on the S's prior experience with the test stimulus.

For Ss familiar with the test stimulus the increase in fear with an increase in age should result in an increase in the speed of response toward the familiar stimulus. No such tendency was observed. For all Ss regardless of familiarity with the stimulus the trend was toward a decrease in speed of response as the age of the S increased.

Since the relationship can not be explained in the context of the present experiment by the perceptual model the importance of the maturational model in predicting behavior in the 'imprinting' situation can not be ignored. The primary deficit of the maturational model is its inability to explain the results supporting the perceptual model.

A Maturational - Perceptual Model

The failure of the perceptual model to explain the decrease in response speed with age occurring after the peak in response speed can be traced to the model's assumption that the fear response to an unfamiliar stimulus is always withdrawal. If this assumption is replaced by an assumption that a maturational shift occurs in the response to an unfamiliar stimulus from a withdrawal response to a freezing (immobility) response then the augmented model could explain the relationship.

The explanation remains the same regardless of whether the test stimulus is familiar or unfamiliar. In either case, the older the S is the more likely S is to freeze (remain immobile) in response to the unfamiliar aspects of the testing situation.

Under the conditions of the present experiment a freezing response was indistinguishable from a withdrawal response. The alley restricted any attempt on the part of the Ss to withdraw and any effort to withdraw was not recorded.

The results reported by Broom (1966), however, support this assumption. He found that the immobility response to a novel stimulus increased with the age at which the novel stimulus was presented.

The results reported by Hess (1959b) do not contradict this assumption. He found that the incidence of fear responses increased with the age at which the novel stimulus was presented.

A S was scored as having emitted a fear response if S emitted either a distress call or a withdrawal response. No indication of the relative importance of the two types of responses in producing the reported increase in fear responses with age was given.

A path diagram of the proposed Maturational - Perceptual model is given in Figure 5. In this figure the response of a S in the imprinting situation is indicated as being a function of both the identification of familiar and unfamiliar stimuli and the potential response of the S to such stimuli. The potential response of the S is indicated as being dependent on the maturation of the S only while the identification of stimuli as familiar or unfamiliar depends both on the stimulus situation and on the S's standard of the perceptually familiar. The S's standard of the perceptually familiar is indicated as being dependent on perceptual learning only.

Further research on the adequacy of this model must provide a method of distinguishing withdrawal response from freezing responses. This could be accomplished by placing the S in the middle of the alley at the fulcrum of the teeter-totter floor and recording not only approach to the stimulus presented at one end of the alley but also withdrawal from that stimulus toward the other end of the alley.

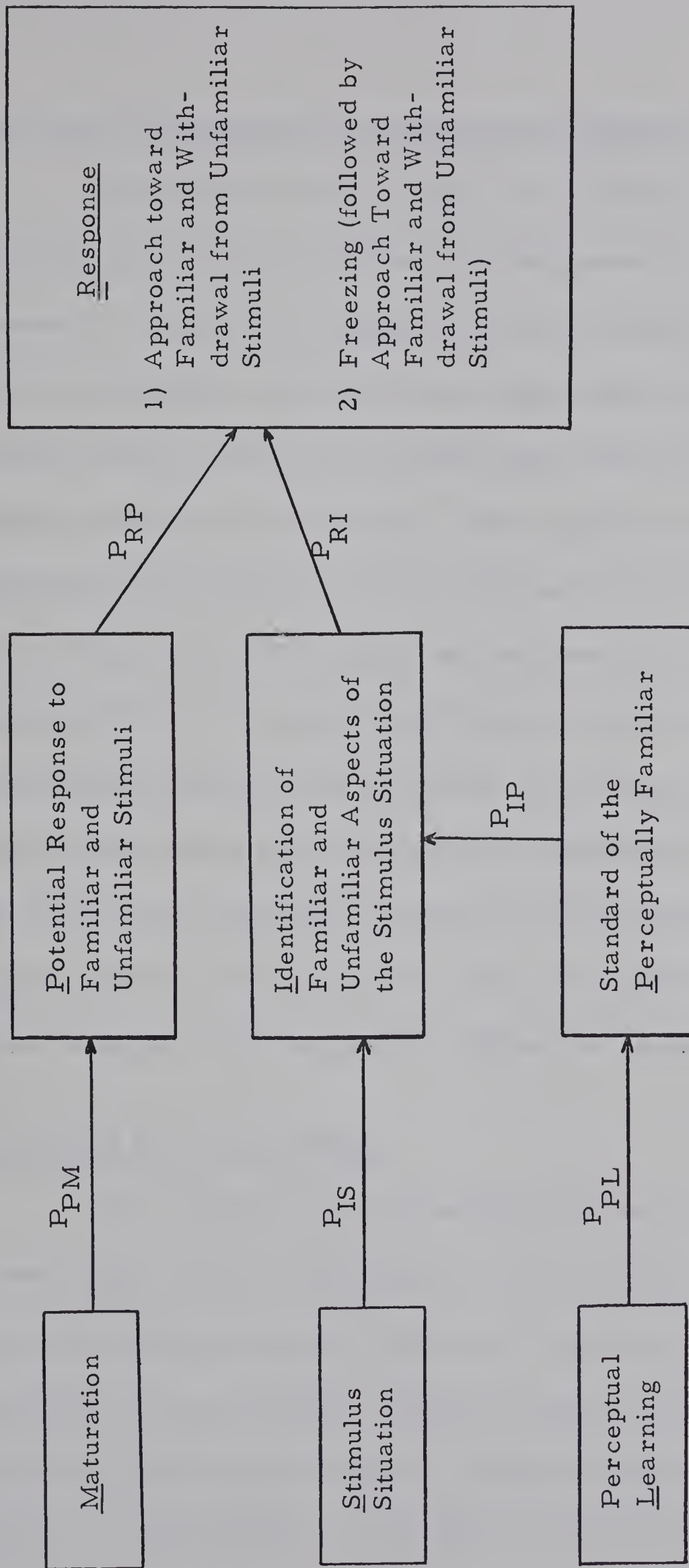


Figure 5. Maturation-Perceptual model: Behavior in the imprinting situation as a function of maturation and perceptual learning.

The Effect of Perceptual Familiarity as a Function of Innate Preference

In the introduction a review of the studies which investigated the effect of perceptual familiarity in the presence of apparent innate preference resulted in a suggestion that pre-exposure to an innately preferred stimulus would interfere more with a subsequent attempt to imprint the S to a different stimulus than would pre-exposure to an innately non-preferred stimulus. This suggestion is supported by the finding that pre-exposure to the preferred stimulus (0.2/0.2 seconds on/off flicker rate) has no effect on imprinting to the non-preferred stimulus (2.8/0.2 seconds on/off flicker rate) while pre-exposure to the non-preferred stimulus facilitates imprinting to the preferred stimulus (See Table 19). The fact that facilitation versus no facilitation rather than little interference versus marked interference was found suggests that the stimuli used (0.2/0.2 and 2.8/0.2 seconds on/off flicker rate) were not sufficiently different to prevent generalization.

Suggestions for Further Study

The complications of generalization not anticipated in the present study could be alleviated in a future study by testing Ss in a free choice situation rather than in an 'imprinting' situation. The possibility of generalization would be reduced by the simultaneous presence of both the pre-exposure stimulus and the 'imprinting' stimulus. Generalization would also be reduced by using stimuli which

elicit more divergent preference responses than the stimuli employed in the present study.

As discussed above the free choice situation should include a choice of withdrawing from both stimuli. This could be accomplished by placing the Ss in a triangular open field with the 'pre-exposure' stimulus at one apex, the 'imprinting' stimulus at another apex, and with the remaining apex left empty. The approach toward either stimuli or the withdrawal into the empty corner could be recorded by micro-switches under three pivoted sections of the floor. A freezing or immobility response would be indicated by the latency of any of the above three responses.

In the present experiment the response of the Ss after seven days of pre-exposure to the test stimulus was not distinguishably different than that of the controls. The response of Ss after either one day or three days of pre-exposure, however, suggests that the lack of response after seven days was not due to a lack of perceptual learning. One possible way to reinstate approach behavior is suggested by the results reported by Candland et al. (1963). They found that after 25 days of familiarization, approach by the S toward the familiar stimuli could be elicited by subjecting the S to a stressful situation. This could be provided in the apparatus suggested by providing the central platform in the triangular field with a grid through which to administer electric shock.

The present investigation, even if repeated with the suggested modifications, deals with only a few of the apparently relevant variables controlling behavior in the 'imprinting' situation. A more complete understanding would require an investigation of generalization and interaction of the effects of pre-hatch stimulus exposure both within and across sensory modalities, as well as a clarification of possible maturational effects of such stimulation. An eventual important consideration will be to determine the mode of inheritance of the relevant maturational processes. Such detailed investigation is well beyond the scope of the present inquiry.

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Appendix A

Cell Mean Age: Hours

Testing Condition (Seconds on/off)

Tray	Pre-natal Exposure Condition (Sec. on/off)	Days of Pre-natal Exposure	0.2/0.2	2.8/0.2	3.8/0.2	4.8/0.2	Constant	Dark
Top	0.2/0.2	1	24.714	21.000	-	-	-	-
		3	24.636	25.909	-	-	-	-
		7	21.833	21.667	-	-	-	-
	2.8/0.2	1	26.273	27.600	-	-	-	-
		3	31.500	26.846	-	-	-	-
		7	33.429	33.462	-	-	-	-
Middle	0.2/0.2	0	23.000	22.391	21.923	21.444	-	-
	2.8/0.2	0	29.737	28.684	-	-	24.739	29.273
	0.2/0.2	1	25.182	24.800	-	-	-	-
3		27.429	28.231	-	-	-	-	
7		21.333	20.455	-	-	-	-	
Bottom	2.8/0.2	1	26.000	28.000	-	-	-	-
		3	30.167	30.143	-	-	-	-
		7	33.154	34.231	-	-	-	-

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